WHAT IS CLAIMED IS:

1. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, an apparatus for calibrating said touch-screen display system comprising:

a processor responsive to digital signals from said touch-screen display system to generate calibrated pixel coordinate estimates as an integral part of real-time generation of said pixel coordinate estimates without needing said user to assist in the calibration effort by touching pre-determined locations on said display screen.

2. The apparatus of claim 1 wherein said digital signals are derived from voltage levels sampled from bus bars of analog resistive screens within said touch-screen display system.

3. The apparatus of claim 2 wherein said voltage levels are converted to said digital signals by a set of analog-to-digital converters within said touch-screen display system.

4. The apparatus of claim 2 wherein said analog resistive screens are powered on and powered off by drivers that apply voltage reference levels to said bus bars of said analog resistive screens.

5. The apparatus of claim 4 wherein said drivers are controlled by said processor.

6. The apparatus of claim 2 wherein said touch-screen display system is configured to sample at least eight independent digital signals corresponding to at least eight independent voltage levels on said bus bars of said analog resistive screens and corresponding to various combinations of said analog resistive screens being powered on, powered off, touched, and not touched.

7. The apparatus of claim 1 wherein said digital signals comprise a first digital signal and a second digital signal and a third digital signal.

8. The apparatus of claim 7 wherein said first digital signal corresponds to a voltage level sampled from a bus bar of a second analog resistive screen of said touch-screen display system that is not powered on and is touching a first analog resistive screen of said touch-screen display system that is powered on.

9. The apparatus of claim 8 wherein said second digital signal corresponds to a ground reference sampled from a first bus bar of said first analog resistive screen.

10. The apparatus of claim 9 wherein said third digital signal corresponds to a voltage reference level sampled from a second bus bar of said first analog resistive screen.

11. The apparatus of claim 10 wherein said processor is programmed to generate a numerator parameter value representing the difference between said first digital signal and said second digital signal.

12. The apparatus of claim 11 wherein said processor is responsive to said third digital signal and said second digital signal to generate a denominator parameter value representing the difference between said third digital signal and said second digital signal.

13. The apparatus of claim 12 wherein said processor is responsive to said numerator parameter value and said denominator parameter value to generate a ratio parameter value representing the ratio of said numerator parameter value and said denominator parameter value.

14. The apparatus of claim 13 wherein said processor is responsive to said ratio parameter value and a number of pixels that fully spans a corresponding axis of said touch-screen display system to generate a calibrated pixel coordinate estimate representing the product of said ratio parameter value and said number of pixels.

15. The apparatus of claim 2 wherein said processor is responsive to said calibrated pixel coordinate estimates to generate corrected calibrated pixel coordinate estimates due to any mismatch between spatial locations of said bus bars of said analog resistive screens and edges of active areas of said analog resistive screens.

16. The apparatus of claim 2 wherein said processor is responsive to said calibrated pixel coordinate estimates to generate corrected calibrated pixel coordinate estimates due to any mismatch between spatial locations of edges of active areas of said analog resistive screens and active areas of a display of said touch-screen display system.

17. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, an apparatus for generating and validating said pixel coordinate estimates comprising:

a processor to determine a first valid pixel coordinate estimate for a first touch-screen axis of said touch-screen display system before determining a second valid pixel coordinate estimate for a second touch-screen axis of said touch-screen display system.

18. The apparatus of claim 17 wherein said processor is adapted to power on said first touch-screen axis of said touch-screen display system and to power off said second touch-screen axis of said touch-screen display system.

19. The apparatus of claim 18 wherein said first touch-screen axis is an x-axis and said second touch-screen axis is a y-axis.

20. The apparatus of claim 18 wherein said processor is adapted to generate a first pixel coordinate estimate corresponding to said first touch-screen axis and a second pixel coordinate estimate corresponding to said first touch-screen axis such that said first pixel coordinate estimate and said second pixel coordinate estimate are separated in time by a pre-determined sampling interval.

21. The apparatus of claim 20 wherein said processor is responsive to said first pixel coordinate estimate of said first touch-screen axis and said second pixel coordinate estimate of said first touch-screen axis to generate a first comparison parameter value.

22. The apparatus of claim 21 wherein said processor is adapted to read a pre-determined first threshold value.

23. The apparatus of claim 22 wherein said processor is adapted to compare said first comparison parameter value to said pre-determined first threshold value.

24. The apparatus of claim 23 wherein said processor is adapted to select said second pixel coordinate estimate of said first touch-screen axis as a first valid pixel coordinate estimate of said first touch-screen axis if said first comparison parameter value is in a first definite relationship to said pre-determined first threshold value.

25. The apparatus of claim 23 wherein said processor is adapted to define said first valid pixel coordinate estimate as invalid if said first comparison parameter value is in a second definite relationship to said pre-determined first threshold value.

26. The apparatus of claim 25 wherein said processor is adapted to make, at most, a pre-determined number of attempts to generate and select said first valid pixel coordinate estimate.

27. The apparatus of claim 25 wherein said processor is adapted to define a "no touch" state as being detected and to generate a "no touch" parameter value to indicate said "no touch" state as being detected when said first valid pixel coordinate estimate is defined as invalid.

28. The apparatus of claim 26 wherein said processor is adapted to define said "no touch" state as being detected by generating a "no touch" parameter value to indicate said "no touch" state as being detected if said pre-determined number of attempts is reached and said processor still defines said first valid pixel coordinate estimate as invalid.

29. The apparatus of claim 17 wherein said processor is adapted to power on said second touch-screen axis of said touch-screen display system and to power off said first touch-screen axis of said touch-screen display system.

30. The apparatus of claim 29 wherein said processor is adapted to generate a first pixel coordinate estimate corresponding to said second touch-screen axis and a second pixel coordinate estimate corresponding to said second touch-screen axis such that said first pixel coordinate estimate and said second pixel coordinate estimate are separated in time by a pre-determined sampling interval.

31. The apparatus of claim 30 wherein said processor is responsive to said first pixel coordinate estimate of said second touch-screen axis and said second pixel coordinate estimate of said second touch-screen axis to generate a second comparison parameter value.

32. The apparatus of claim 31 wherein said processor is adapted to read a pre-determined second threshold value.

33. The apparatus of claim 32 wherein said processor is adapted to compare said second comparison parameter value to said pre-determined second threshold value.

34. The apparatus of claim 33 wherein said processor is adapted to select said second pixel coordinate estimate of said second touch-screen axis as a second valid pixel coordinate estimate of said second touch-screen axis if said second comparison parameter value is in a first definite relationship to said pre-determined second threshold value.

35. The apparatus of claim 33 wherein said processor is adapted to define said second valid pixel coordinate estimate as invalid if said second comparison parameter value is in a second definite relationship to said pre-determined second threshold value.

36. The apparatus of claim 35 wherein said processor is adapted to generate and select said first valid pixel coordinate estimate corresponding to said first touch-screen axis before making another attempt to generate and select said second valid pixel coordinate estimate corresponding to said second touch-screen axis.

37. The apparatus of claim 36 wherein said processor is adapted to make, at most, a pre-determined number of attempts to generate and select said second valid pixel coordinate estimate.

38. The apparatus of claim 35 wherein said processor is adapted to define a “no touch” state as being detected and to generate a “no touch” parameter value to indicate said “no touch” state as being detected when said second valid pixel coordinate estimate is defined as invalid.

39. The apparatus of claim 37 wherein said processor is adapted to define said “no touch” state as being detected by generating a “no touch” parameter value to indicate said “no touch” state as being detected if said pre-determined number of attempts is reached and said processor still defines said second valid pixel coordinate estimate as invalid.

40. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, an apparatus for enabling detection of a “no touch” state of said touch-screen display system comprising:

at least one bus bar;

at least one driver electrically connected to said at least one bus bar to selectively switch said at least one bus bar between at least two of a plurality of electrical potentials; and

at least one shunt electrically connected across said at least one driver.

41. The apparatus of claim 40 wherein said plurality of electrical potentials comprises a plurality of voltage levels with respect to an electrical ground representative of said pixel coordinate estimates.

42. The apparatus of claim 41 wherein said at least one driver comprises a transistor.

43. The apparatus of claim 42 wherein said transistor comprises an emitter terminal and a collector terminal.

44. The apparatus of claim 43 wherein said at least one shunt is electrically connected across said collector terminal and said emitter terminal of said transistor.

45. The apparatus of claim 43 wherein said collector terminal is electrically connected to said at least one bus bar and said emitter terminal is electrically connected to said electrical ground.

46. The apparatus of claim 40 wherein said at least one shunt comprises a resistor.

47. The apparatus of claim 41 wherein said at least one shunt provides an impedance path from said at least one bus bar to said electrical ground.

48. The apparatus of claim 40 wherein said at least one shunt determines, at least in part, a settling time (discharge rate) corresponding to at least one analog interface of said touch-screen display system.

49. The apparatus of claim 41 wherein said at least one bus bar is electrically connected to said electrical ground through said at least one driver when said at least one driver is powered on.

50. The apparatus of claim 41 wherein said at least one bus bar is at one of said plurality of voltage levels when said at least one driver is powered off and said display screen is being touched by a user.

51. The apparatus of claim 41 wherein said at least one bus bar is electrically connected to said electrical ground through said shunt when said at least one driver is powered off and said display screen is not being touched by a user.

52. The apparatus of claim 41 further comprising at least one analog-to-digital converter electrically connected to said at least one bus bar to convert said plurality of voltage levels to a plurality of digital values representing said plurality of voltage levels.

53. The apparatus of claim 52 further comprising a processor responsive to said plurality of digital values for subsequent detection of said "no touch" state.

54. The apparatus of claim 48 wherein a threshold value is determined, at least in part, by said settling time (discharge rate) and said sampling rate, and is used in determining the validity of said pixel coordinate estimates.

55. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, a method for calibrating axes of said touch-screen display system comprising:

generating calibrated pixel coordinate estimates in response to digital signals from said touch-screen display system as an integral part of real-time generation of said pixel coordinate estimates without needing said user to assist in the calibration effort by touching pre-determined locations on said display screen.

56. The method of claim 55 further comprising generating said digital signals from voltage levels sampled from reference points of said axes within said touch-screen display system.

57. The method of claim 56 further comprising converting said voltage levels to said digital signals within said touch-screen display system.

58. The method of claim 56 further comprising powering on and powering off said reference points using driving techniques to apply voltage reference levels to said reference points.

59. The method of claim 56 further comprising sampling at least eight independent digital signals corresponding to at least eight independent voltage levels on said reference points and corresponding to various combinations of said reference points of said axes being powered on and powered off, and said touch-screen display system being touched and not touched.

60. The method of claim 55 wherein said digital signals comprise a first digital signal and a second digital signal and a third digital signal.

61. The method of claim 60 wherein said first digital signal corresponds to a voltage level sampled from a second reference point of a second axis of said touch-screen display system that is not powered on but is electrically touching a first axis of said touch-screen display system that is powered on.

62. The method of claim 61 wherein said second digital signal corresponds to a ground reference sampled from a first reference point of said first axis.

63. The method of claim 62 wherein said third digital signal corresponds to a voltage reference level sampled from a second reference point of said first axis.

64. The method of claim 63 further comprising generating a numerator parameter value representing the difference between said first digital signal and said second digital signal.

65. The method of claim 64 further comprising generating a denominator parameter value representing the difference between said third digital signal and said second digital signal.

66. The method of claim 65 further comprising generating a ratio parameter value representing the ratio of said numerator parameter value and said denominator parameter value.

67. The method of claim 66 further comprising generating a calibrated pixel coordinate estimate representing the product of said ratio parameter value and a number of pixels that fully spans a corresponding axis of said touch-screen display system.

68. The method of claim 56 further generating corrected calibrated pixel coordinate estimates from said calibrated pixel coordinate estimates correcting for any mismatch between spatial locations of said reference points and edges of active areas of said touch-screen display system.

69. The method of claim 56 further comprising generating corrected calibrated pixel coordinate estimates from said calibrated pixel coordinate estimates correcting for any mismatch between various spatial locations of edges of active areas of said touch-screen display system.

70. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, a method for generating and validating said pixel coordinate estimates comprising:

generating and determining the validity of a first valid pixel coordinate estimate for a first touch-screen axis of said touch-screen display system before generating and determining the validity of a second valid pixel coordinate estimate for a second touch-screen axis of said touch-screen display system.

71. The method of claim 70 further comprising powering on said first touch-screen axis of said touch-screen display system and powering off said second touch-screen axis of said touch-screen display system.

72. The method of claim 71 wherein said first touch-screen axis is an x-axis and said second touch-screen axis is a y-axis.

73. The method of claim 71 further comprising generating a first pixel coordinate estimate corresponding to said first touch-screen axis and a second pixel coordinate estimate corresponding to said first touch-screen axis such that said first pixel coordinate estimate and said second pixel coordinate estimate are separated in time by a pre-determined sampling interval.

74. The method of claim 73 further comprising generating a first comparison parameter value from said first pixel coordinate estimate of said first touch-screen axis and said second pixel coordinate estimate of said first touch-screen axis.

75. The method of claim 74 further comprising comparing said first comparison parameter value to a pre-determined first threshold value.

76. The method of claim 75 further comprising selecting said second pixel coordinate estimate of said first touch-screen axis as a first valid pixel coordinate estimate of said first touch-screen axis if said first comparison parameter value is in a first definite relationship to said pre-determined first threshold value.

77. The method of claim 75 further comprising defining said first valid pixel coordinate estimate as invalid if said first comparison parameter value is in a second definite relationship to said pre-determined first threshold value.

78. The method of claim 77 further comprising making, at most, a pre-determined number of attempts to generate and select said first valid pixel coordinate estimate.

79. The method of claim 77 further comprising defining a "no touch" state as being detected and generating a "no touch" parameter value to indicate said "no touch" state as being detected when said first valid pixel coordinate estimate is defined as invalid.

80. The method of claim 78 further comprising a "no touch" state as being detected by generating a "no touch" parameter value to indicate said "no touch" state as being detected if said pre-determined number of attempts is reached and said first valid pixel coordinate estimate is still defined as invalid.

81. The apparatus of claim 70 further powering on said second touch-screen axis of said touch-screen display system and powering off said first touch-screen axis of said touch-screen display system.

82. The method of claim 81 further generating a first pixel coordinate estimate corresponding to said second touch-screen axis and a second pixel coordinate estimate corresponding to said second touch-screen axis such that said first pixel coordinate estimate and said second pixel coordinate estimate are separated in time by a pre-determined sampling interval.

83. The method of claim 82 further comprising generating a second comparison parameter value from said first pixel coordinate estimate of said second touch-screen axis and said second pixel coordinate estimate of said second touch-screen axis.

84. The method of claim 83 further comprising comparing said second comparison parameter value to a pre-determined second threshold value.

85. The method of claim 84 further comprising selecting said second pixel coordinate estimate of said second touch-screen axis as a second valid pixel coordinate estimate of said second touch-screen axis if said second comparison parameter value is in a first definite relationship to said pre-determined second threshold value.

86. The method of claim 84 further comprising defining said second valid pixel coordinate estimate as invalid if said second comparison parameter value is in a second definite relationship to said pre-determined second threshold value.

87. The method of claim 86 further comprising generating and selecting said first valid pixel coordinate estimate corresponding to said first touch-screen axis before again attempting to generate and select said second valid pixel coordinate estimate corresponding to said second touch-screen axis.

88. The method of claim 87 further comprising making, at most, a pre-determined number of attempts to generate and select said second valid pixel coordinate estimate.

89. The method of claim 86 further comprising defining a "no touch" state as being detected and generating a "no touch" parameter value to indicate said "no touch" state as being detected when said second valid pixel coordinate estimate is defined as invalid.

90. The method of claim 88 further comprising said "no touch" state as being detected by generating a "no touch" parameter value to indicate said "no touch" state as being detected if said pre-determined number of attempts is reached and said second valid pixel coordinate estimate is still defined as invalid.

91. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, a method for enabling detection of a "no touch" state of said touch-screen display system comprising:

selectively switching at least one reference point of at least one axis of said touch-screen display system between at least two of a plurality of electrical potentials by employing electrical driving techniques and electrical shunting techniques.

92. The method of claim 91 wherein said plurality of electrical potentials comprises a plurality of voltage levels with respect to an electrical ground representative of said pixel coordinate estimates.

93. The method of claim 91 wherein at least two of said plurality of electrical potentials comprise a voltage reference level and an electrical ground.

94. The method of claim 92 further comprising providing an impedance path from said at least one reference point of said at least one axis to said electrical ground using said electrical shunting techniques.

95. The method of claim 91 further comprising establishing a settling time (discharge rate) of said at least one reference point using said electrical shunting techniques.

96. The method of claim 92 further comprising electrically connecting said at least one reference point of said at least one axis to said electrical ground when said at least one axis is powered on, using said electrical driving techniques.

97. The method of claim 92 wherein said at least one reference point of said at least one axis is at one of said plurality of voltage levels when said at least one axis is powered off and said user is touching said touch-screen display system.

98. The method of claim 94 further comprising electrically connecting said at least one reference point of said at least one axis to said electrical ground through said impedance path when said at least one axis is powered off and said user is not touching said touch-screen display system, using said electrical driving techniques.

99. The method of claim 92 further comprising converting said plurality of voltage levels to a plurality of digital signals representing said plurality of voltage levels.

100. The method of claim 99 further comprising processing said plurality of digital signals for subsequent detection of said "no touch" state.

101. The method of claim 95 further comprising pre-determining a threshold value from, at least in part, said settling time (discharge rate) of said at least one reference point and said sampling rate, and using said threshold value in determining the validity of said pixel coordinate estimates.

102. A method of determining a touch screen coordinate for a touch screen comprising the steps of:

turning on the driver of the coordinate to be measured;

measuring minimum, maximum, and raw position data for the coordinate being measured; and

determining the coordinate position as a function of the raw position in relation to a coordinate range.

103. The method of claim 102 wherein the range is determined as a function of the difference between the minimum and maximum position data.

104. The method of claim 103 wherein the positioning determining step includes subtracting the minimum position data from the raw position data.

105. The method of claim 104 wherein the raw, minimum and maximum position data are used to calibrate the touch screen without requiring specific calibration using input.

106. The method of claim 104 including the further step of turning off the driver of a coordinate not being measured.

107. The method of claim 104 wherein the foregoing steps are repeated for the other driver whose coordinate is to be determined.

108. An apparatus determining a touch screen coordinate for a touch screen comprising:

means for turning on the driver of the coordinate to be measured;

means for measuring minimum, maximum, and raw position data for the coordinate being measured; and

means for determining the coordinate position as a function of the raw position in relation to a coordinate range.

109. The apparatus of claim 108 wherein the coordinate range is determined as a function of the difference between the minimum and maximum position data.

110. The apparatus of claim 109 wherein the positioning determining means includes means for subtracting the minimum position data from the raw position data.

111. The apparatus of claim 110 wherein the raw, minimum and maximum position data are used to calibrate the touch screen without requiring specific calibration using input.

112. The apparatus of claim 110 further including means for turning off the driver of a coordinate not being measured.

113. A method of determining whether or not a touch screen has been touched comprising the steps of:

providing an analog to digital converter which supplies an analog to digital reading;

reading a minimum bit level;

determining whether the reading is smaller than the minimum bit level; and

determining the absence of a user touch if the modified reading is less than the minimum bit level.

114. The method of claim 113 wherein the reading step includes the use of a pull down resistor.

115. Apparatus determining whether or not a touch screen has been touched comprising:

means for providing an analog to digital reading from an analog to digital converter;

means for reading a minimum bit level;

means for determining whether the reading is smaller than the minimum bit level; and

means for determining the absence of a user touch if the reading is less than a minimum bit level.

116. The apparatus of claim 115 wherein the providing means includes a pull down resistor.

117. A method of speeding up the reading of analog to digital converter signals to a touch screen comprising the steps of:

reading a first coordinate of a coordinate pair at a first time;

consecutively reading the same coordinate at a second time;

determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

quantifying, responsive to the difference determining step the coordinate position as a function of the first or the consecutive coordinate.

118. The method of claim 117 wherein the consecutive coordinate is used as the coordinate position.

119. The method of claim 118 wherein the steps are repeated for the other desired coordinate position.

120. Apparatus speeding up the reading of analog to digital converter signals to a touch screen comprising:

means for reading a first coordinate of a coordinate pair at a first time;

means for consecutively reading the same coordinate at a second time;

means for determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

means, response to the determining means, for quantifying the coordinate position as a function of the first or the consecutive coordinate.

121. The apparatus of claim 120 wherein the consecutive coordinate is used as the coordinate position.

122. A method of determining whether or not a touch screen has been touched comprising the steps of:

reading a first coordinate of a coordinate pair at a first time;

consecutively reading the same coordinate at a second time;

determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

quantifying, responsive to the difference determining step the coordinate position as a function of the first or the consecutive coordinate.

123. The method of claim 117 wherein the consecutive coordinate is used as the coordinate position.

124. The method of claim 118 wherein the steps are repeated for the other desired coordinate position.

125. Apparatus determining whether a touch screen has been touched comprising:

means for reading a first coordinate of a coordinate pair at a first time;

means for consecutively reading the same coordinate at a second time;

means for determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

means, response to the determining means, for quantifying the coordinate position as a function of the first or the consecutive coordinate.

126. The apparatus of claim 120 wherein the consecutive coordinate is used as the coordinate position.

127. A method of eliminating noise from the reading of analog to digital converter signals to a touch screen comprising the steps of:

reading a first coordinate of a coordinate pair at a first time;

consecutively reading the same coordinate at a second time;

determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

quantifying, responsive to the difference determining step the coordinate position as a function of the first or the consecutive coordinate.

128. The method of claim 117 wherein the consecutive coordinate is used as the coordinate position.

129. The method of claim 118 wherein the steps are repeated for the other desired coordinate position.

130. Apparatus eliminating noise from the reading of analog to digital converter signals to a touch screen comprising:

means for reading a first coordinate of a coordinate pair at a first time;

means for consecutively reading the same coordinate at a second time;

means for determining if the absolute value of the difference between the first coordinate and the consecutive coordinate is less than a predetermined value; and

means, response to the determining means, for quantifying the coordinate position as a function of the first or the consecutive coordinate.

131. The apparatus of claim 120 wherein the consecutive coordinate is used as the coordinate position.

132. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, an apparatus for enabling detection of a "no touch" state of said touch-screen display system comprising:

at least one bus bar;

at least one driver electrically connected to said at least one bus bar to selectively switch said at least one bus bar between at least two of a plurality of electrical potentials wherein the at least one driver is selected to have an off state impedance establishing a pre-determined discharge rate.

133. In a touch-screen display system for generating pixel coordinate estimates responsive to a user touching a display screen, an apparatus for enabling detection of a "no touch" state of said touch-screen display system comprising:

at least one bus bar;

at least one driver electrically connected to said at least one bus bar to selectively switch said at least one bus bar between at least two of a plurality of electrical potentials wherein the at least one driver is controlled to establish pre-determined discharge rates.

134. A method of determining whether or not a touch screen has been touched comprising the steps of:

providing an analog to digital converter which supplies an analog to digital reading;

reading a maximum bit level;

determining whether the reading is smaller than the maximum bit level; and

determining the absence of a user touch if the modified reading is less than the maximum bit level.

135. The method of claim 113 wherein the reading step includes the use of a pull up resistor.

136. Apparatus determining whether or not a touch screen has been touched comprising:

means for providing an analog to digital reading from an analog to digital converter;

means for reading a maximum bit level;

means for determining whether the reading is smaller than the maximum bit level; and

means for determining the absence of a user touch if the reading is less than a maximum bit level.

137. The apparatus of claim 115 wherein the providing means includes a pull up resistor.